Title: Fiber Optic TOAD (Time Of Arrival Diagnostic) shock break out validation using PDV.

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I was asked to developing a new type Fiber Optical TOAD (Time Of Arrival Diagnostic).

List of requirements.

- **Made with off the shelf components.**
- **Eye safe.**
- **The Fiber Optical TOAD probe, needs to be low cost and have high precision.**
- **The Fiber Optic TOAD needs to measure the detonation wave arrival time on explosive experiments.**
- **Validate that Fiber Optic TOAD arrival time is correct, with a second diagnostic.(PDV)**
- **Easy to field.**

NNSA National Nuclear Security Administration

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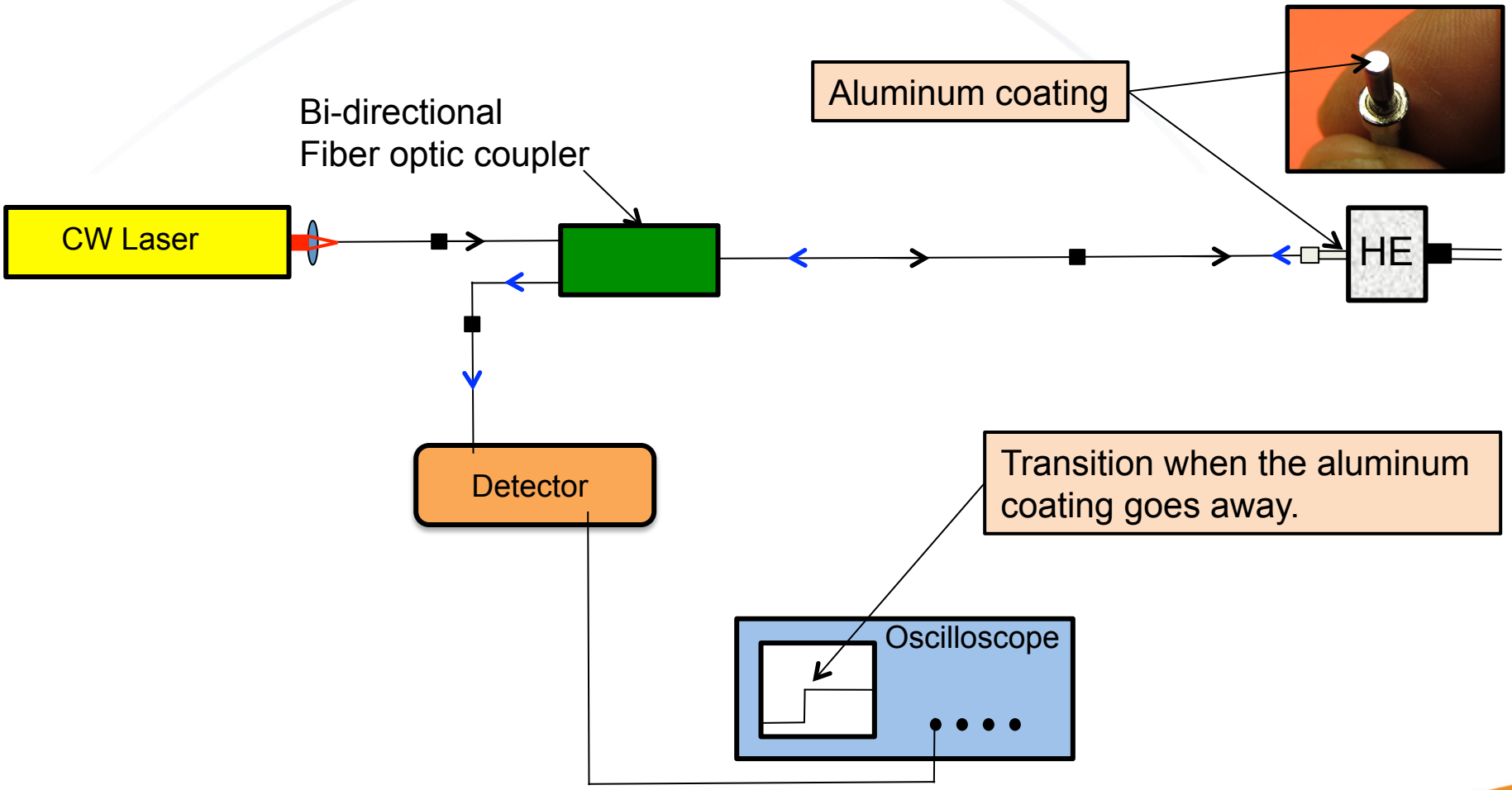
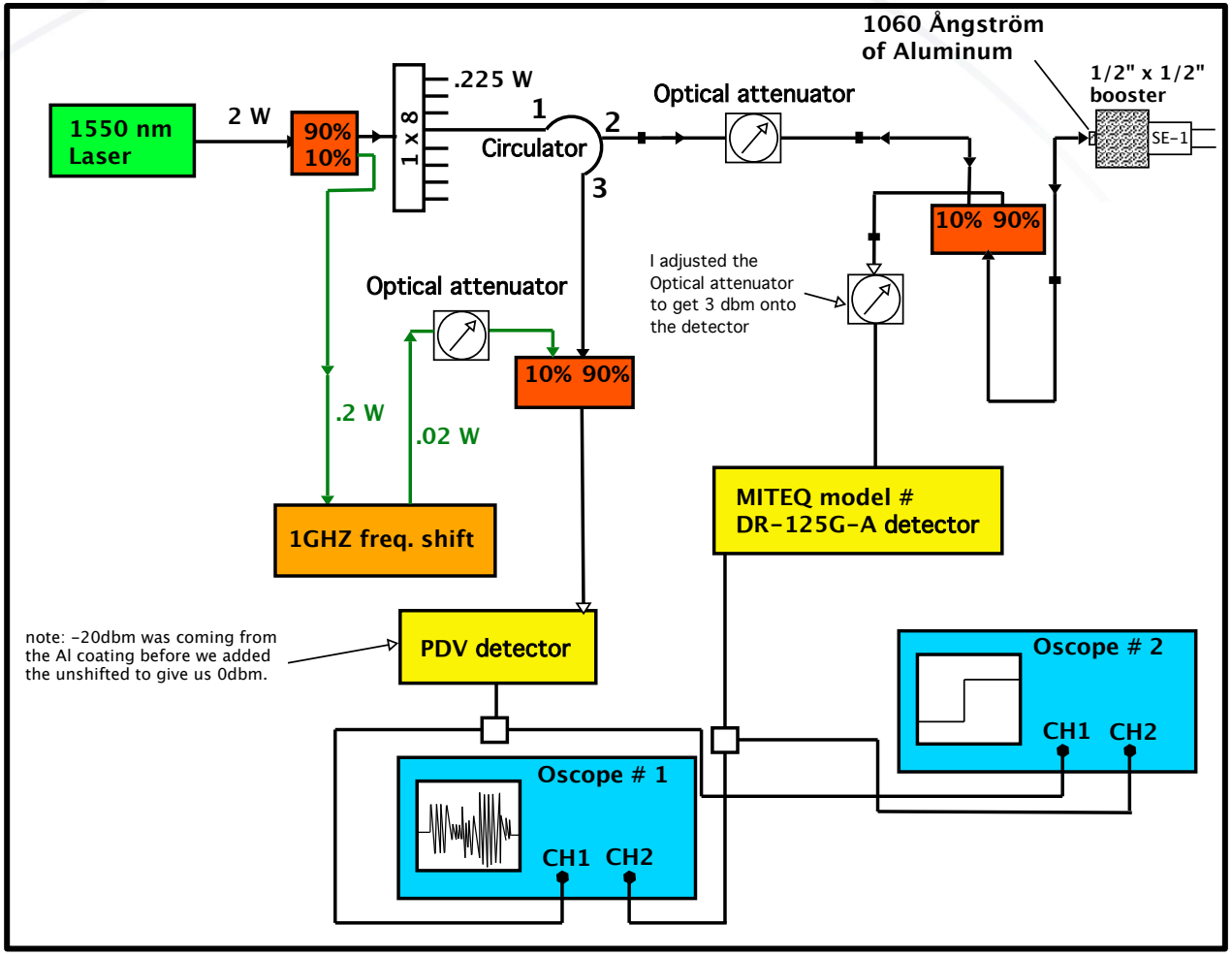
Description of the Fiber Optic TOAD.



Experimental set up to test and validate the Fiber Optic TOAD measurement.



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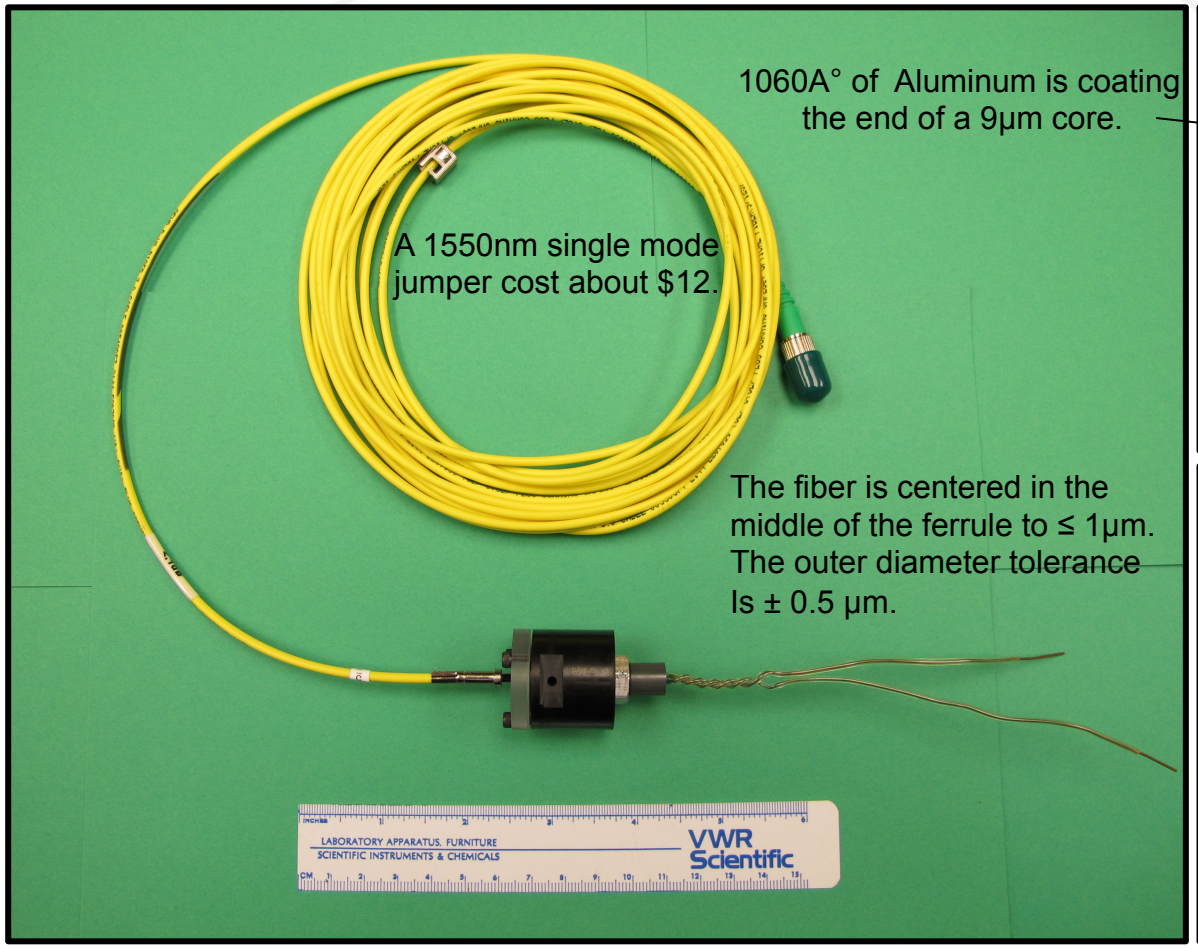
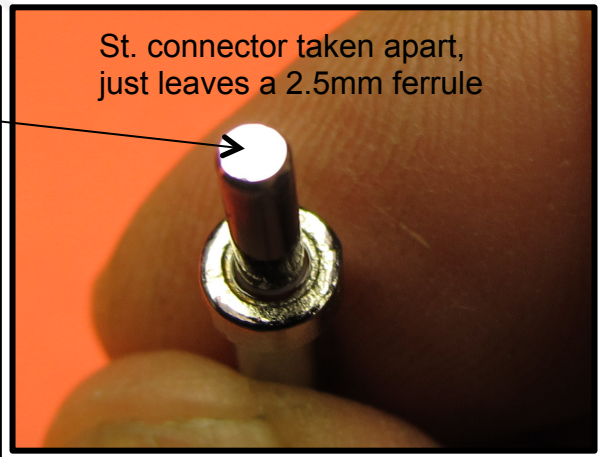
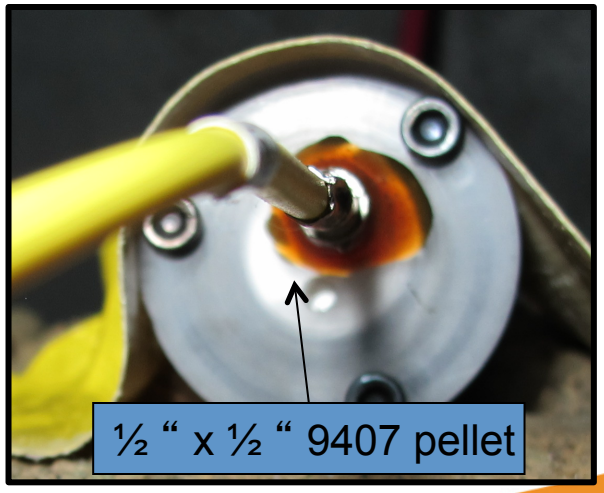
Experimental package for bare HE shot and fiber optic TOAD probe.

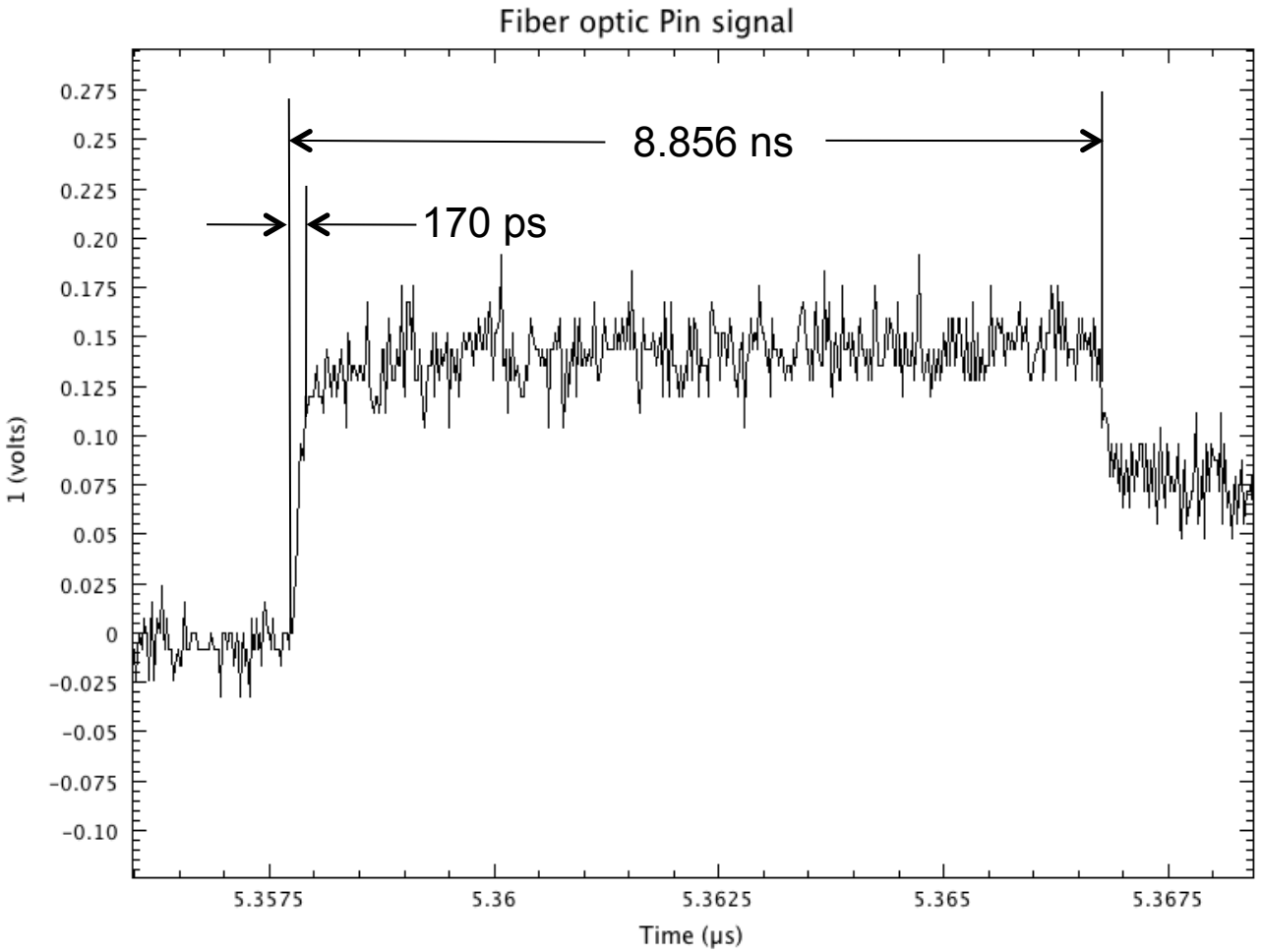




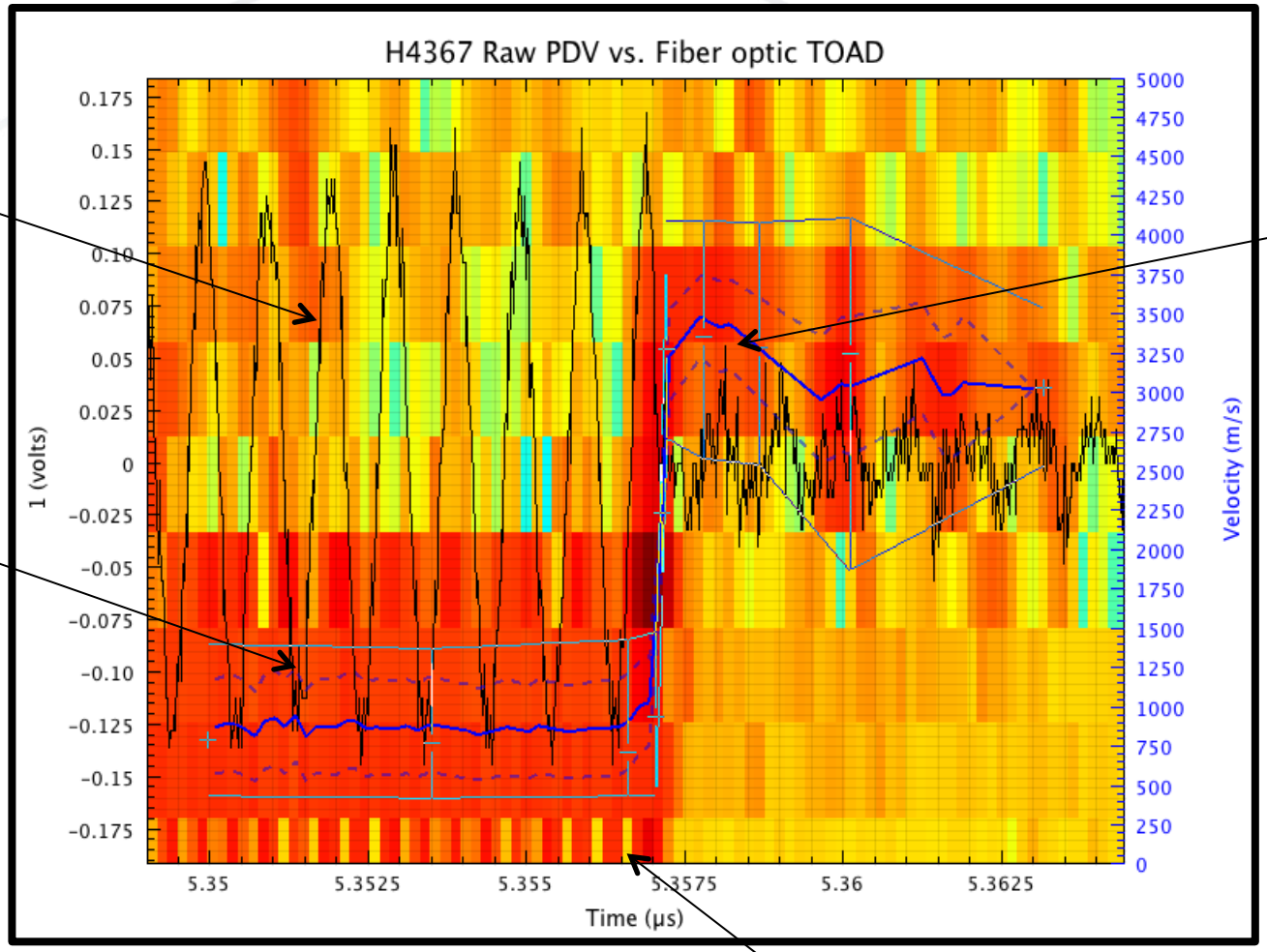


Fiber Optic TOAD Data, bare HE shot.

Note:
A 12.5Ghz detector can see a 80 ps event, the oscilloscope was set to 50Gs/s so the scope was taking a sample every 20 ps.



PDV data bare HE shot



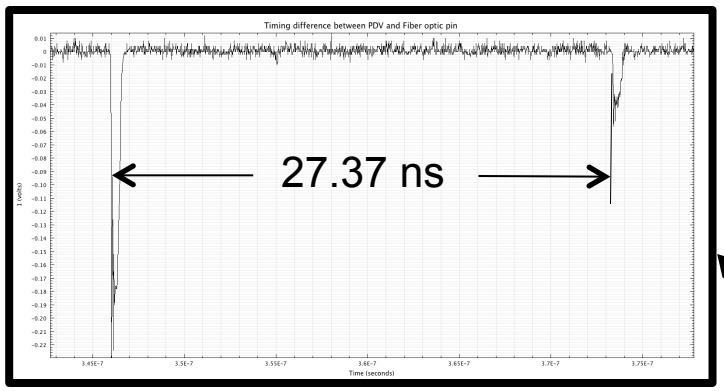
Raw data

ROI

Jump up to
≈ 2.6 km/s

Window size 1.28ns
Window steps 160ps

Timing correction between the Fiber optic TOAD signal and the PDV record.



1550 nm Laser
2 W
90% 10%
1 x 8
.225 W
1
Circulator
2
3
Optical attenuator
30 ps pulsed laser
10% 90%
Optical attenuator
10% 90%
.2 W
.02 W
1GHZ freq. shift
MITEQ model # DR-125G-A detector
PDV detector
Oscope # 1
CH1 CH2

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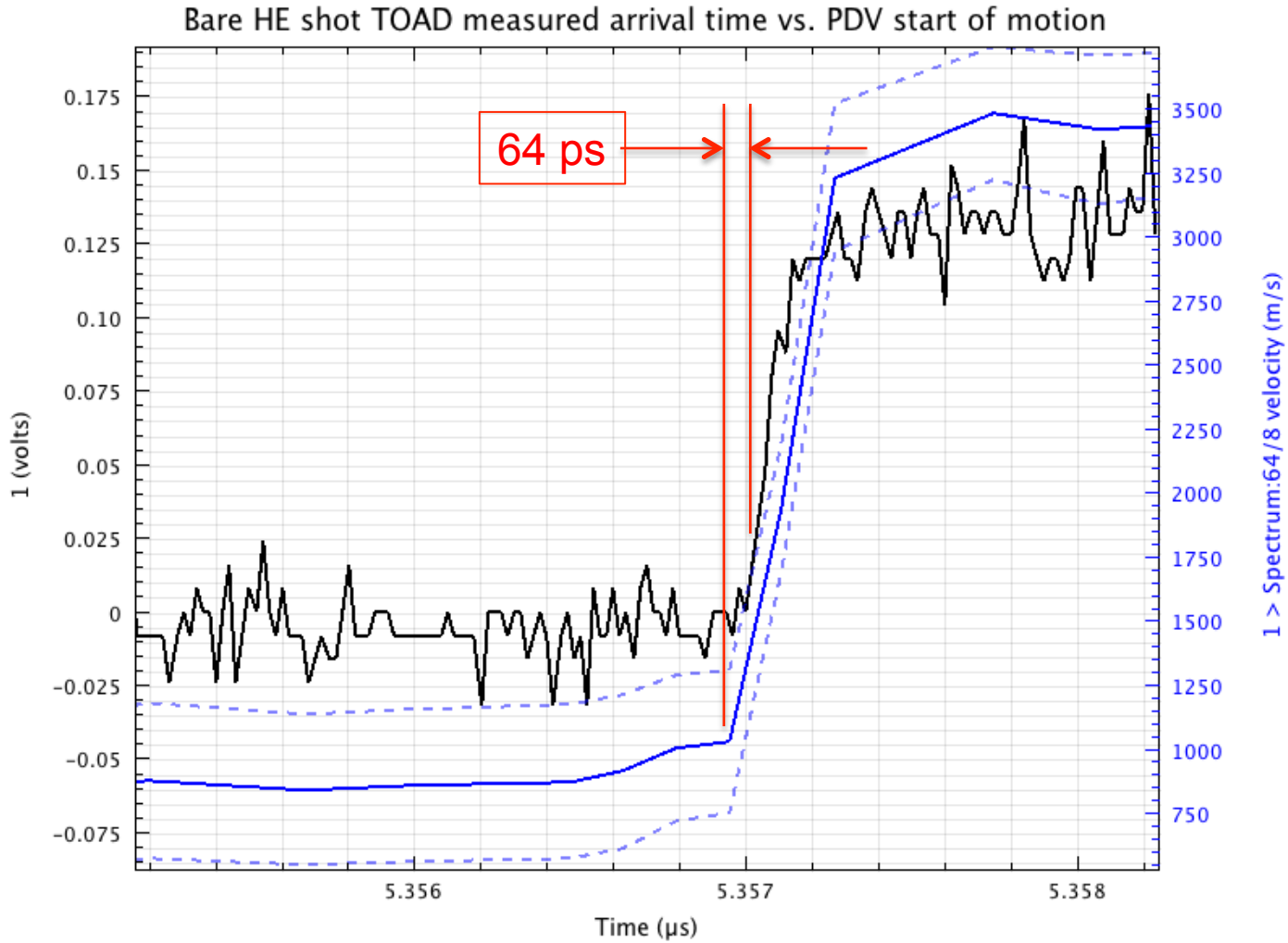
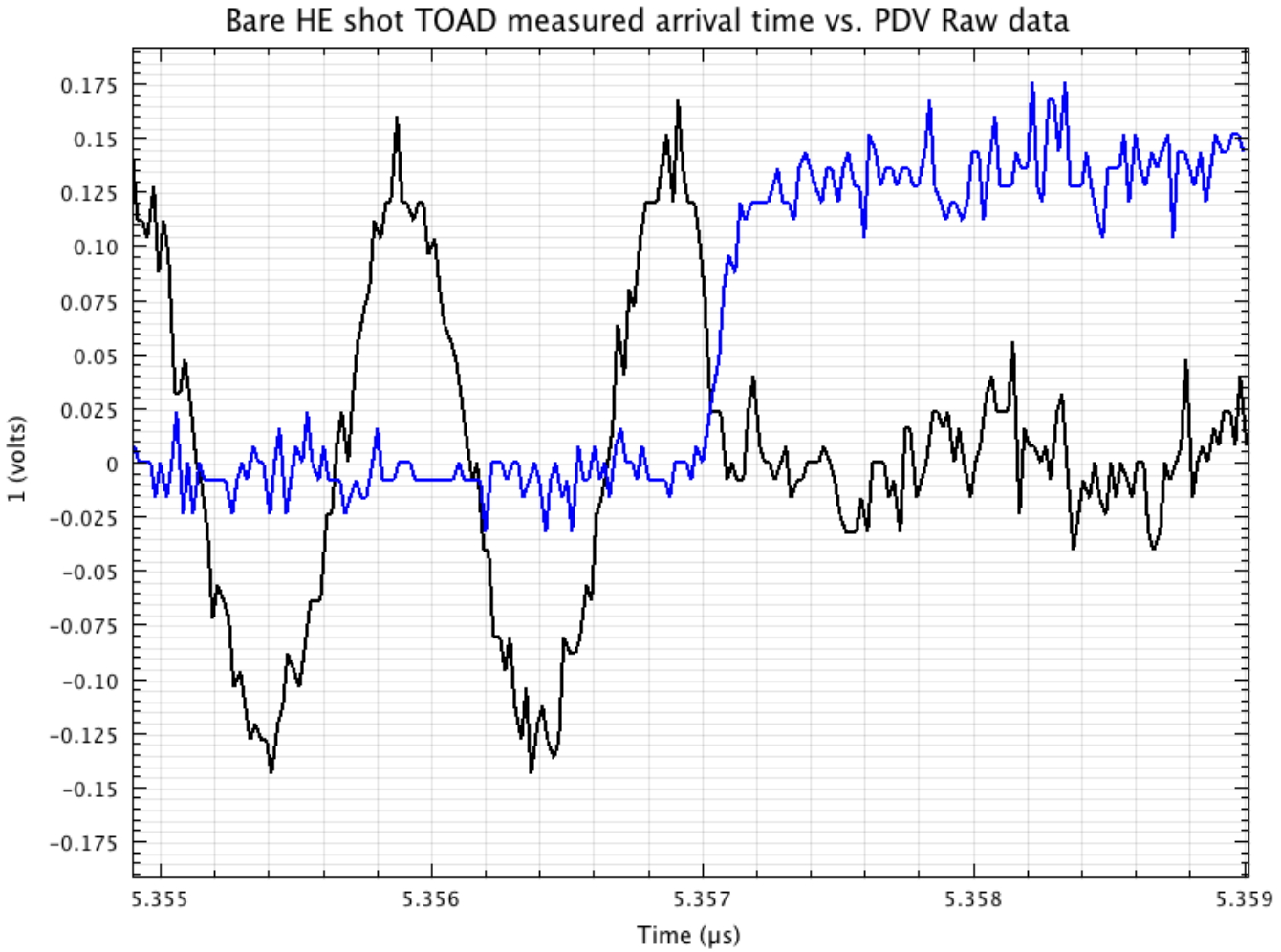
TOAD measured arrival time vs. PDV, with time corrections applied.

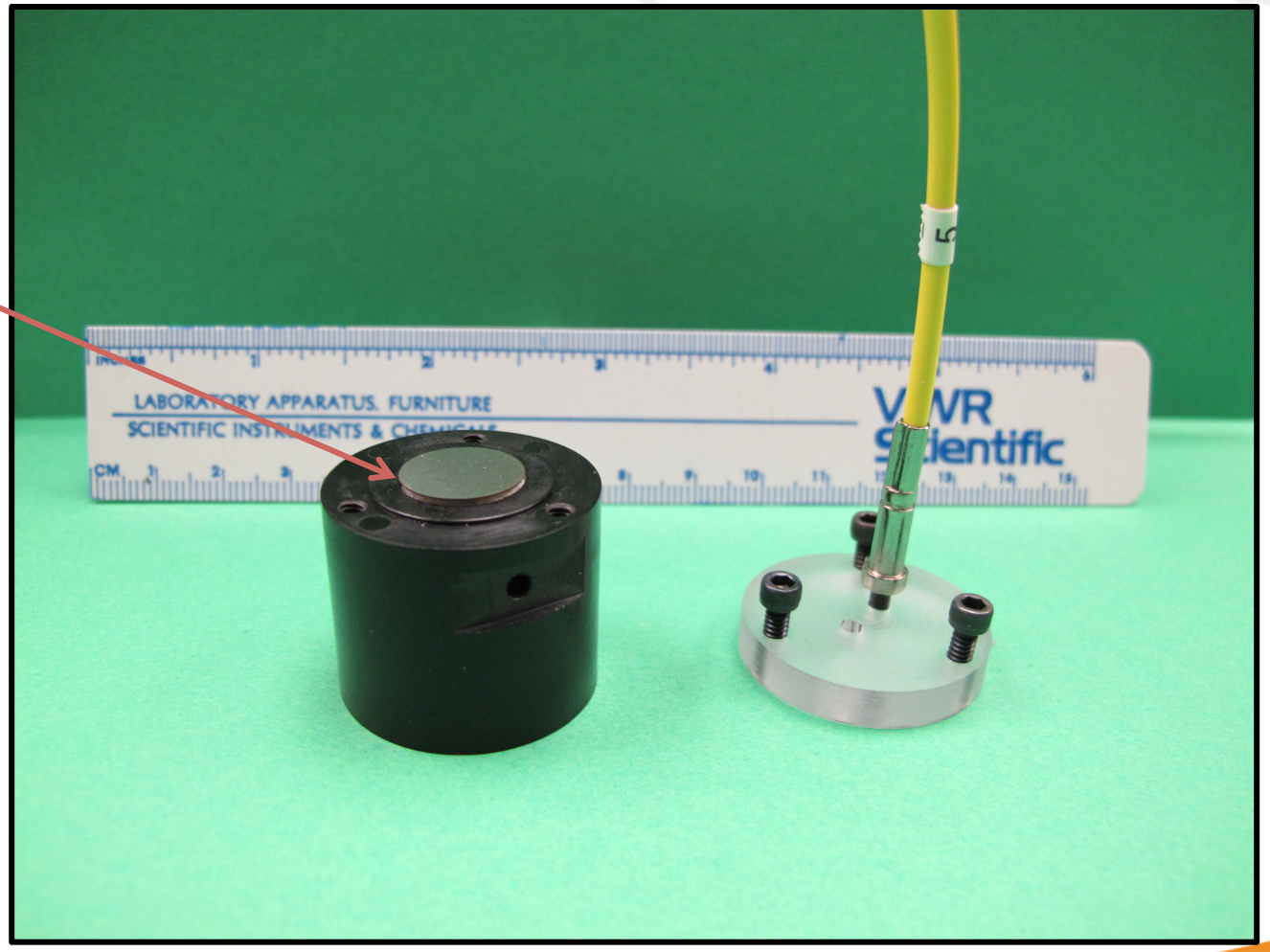


TOAD vs. PDV raw data.

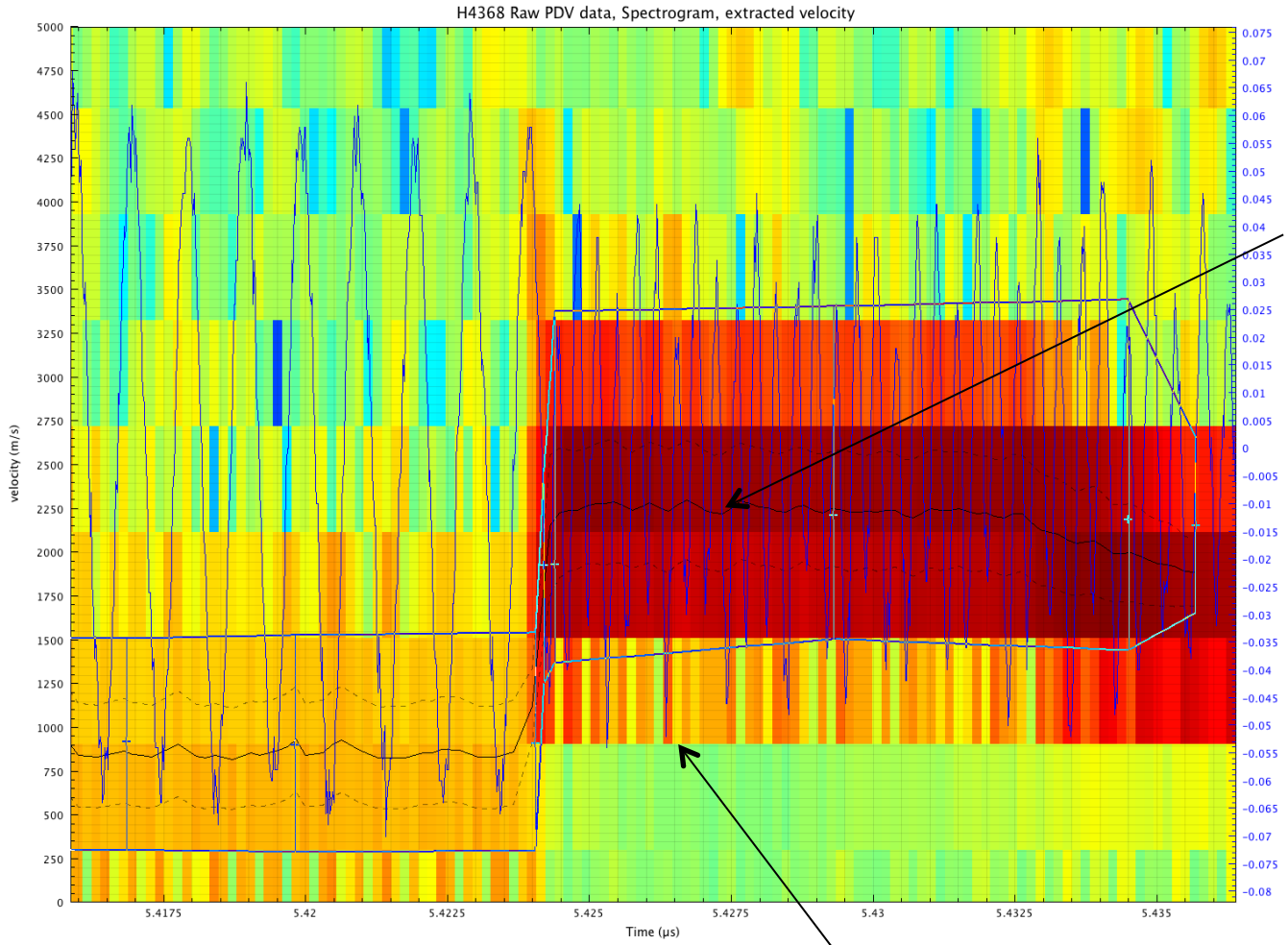


.010 inch Stainless steel Shim disks was glued to booster pellet.

McMaster-Carr part # 2895T51
Type 302/304 Stainless Steel
Shim Disc 1/2" Diameter,
.01" Thick



PDV Data with .010” shim stock



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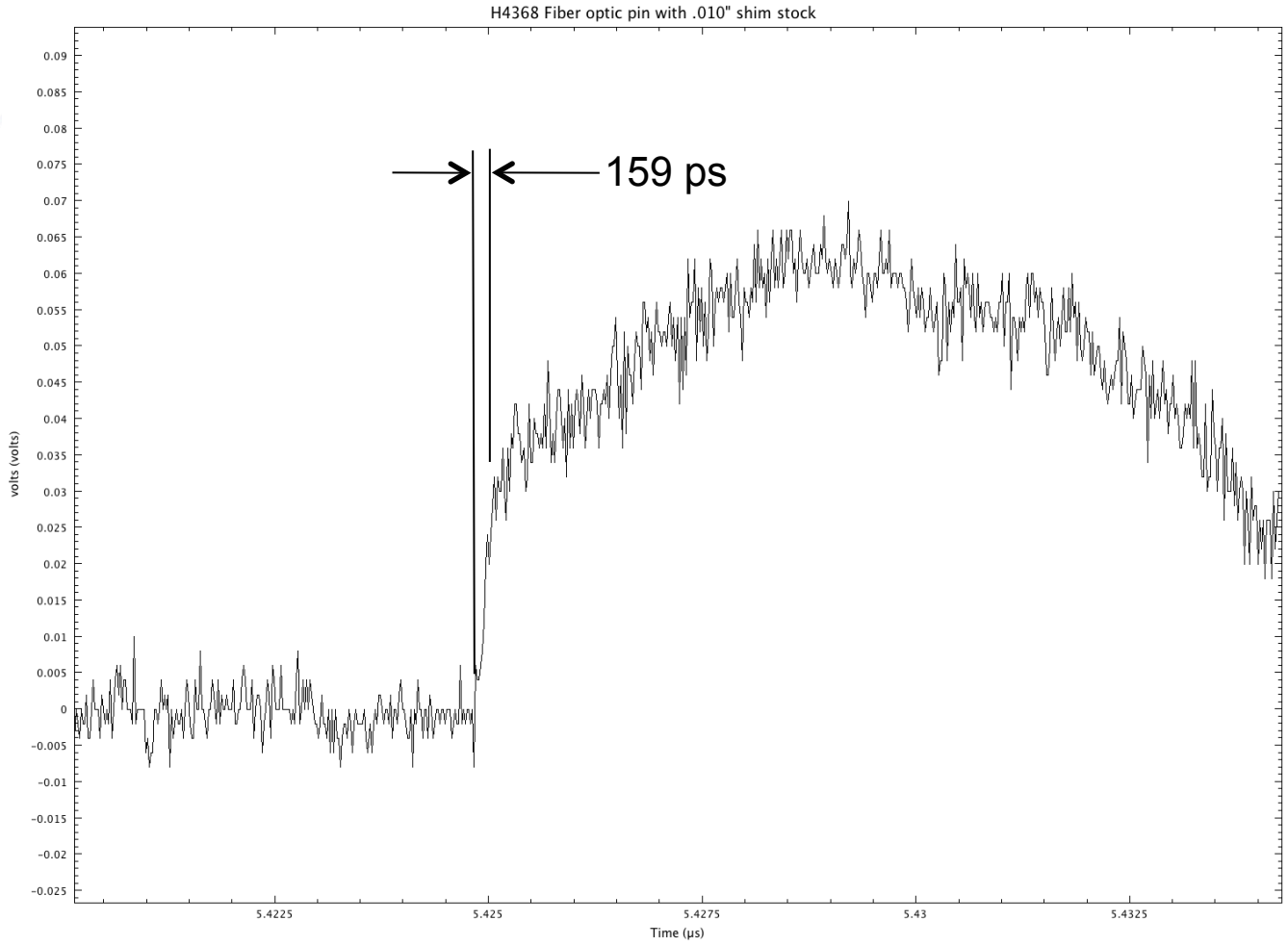
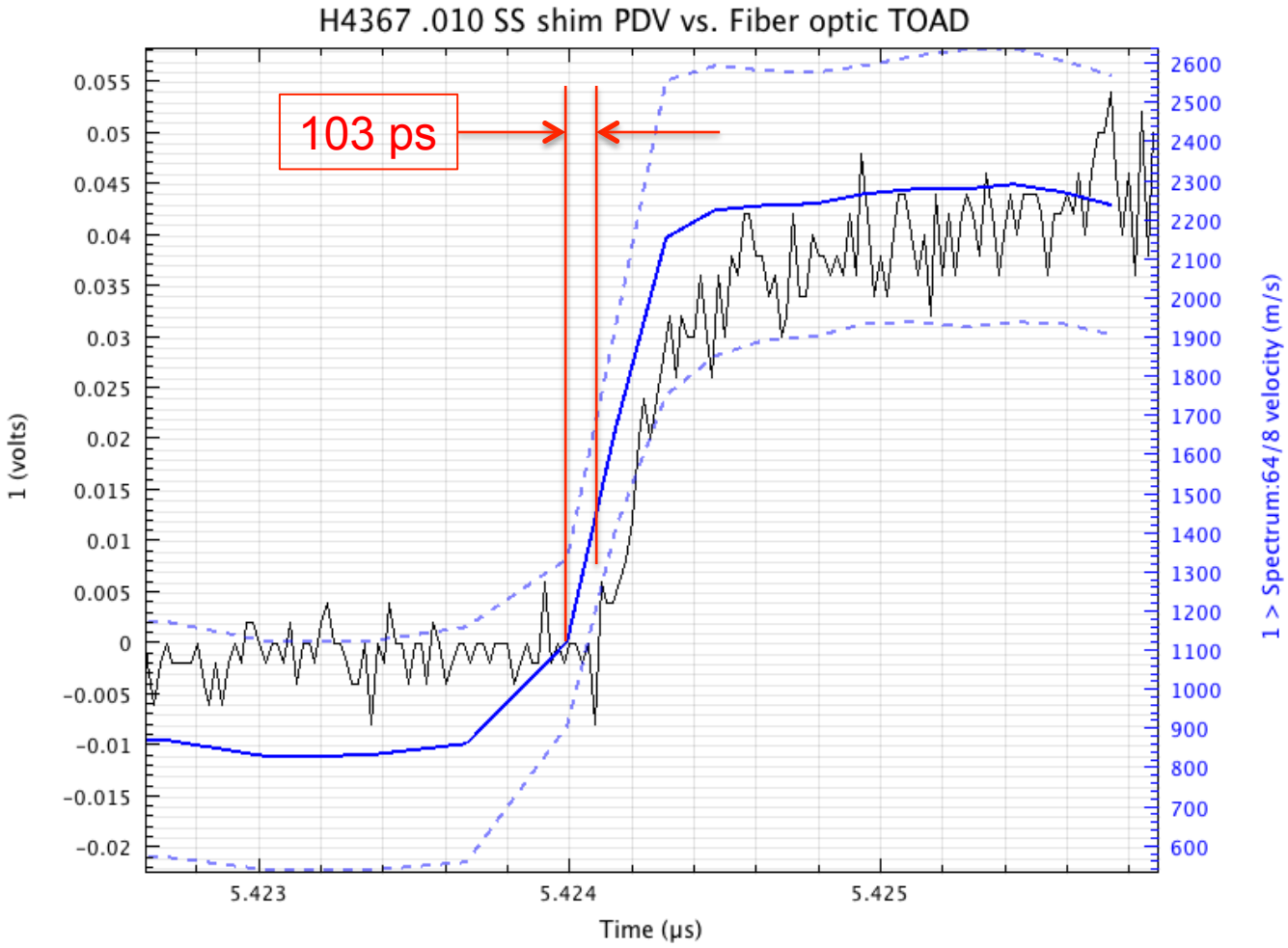
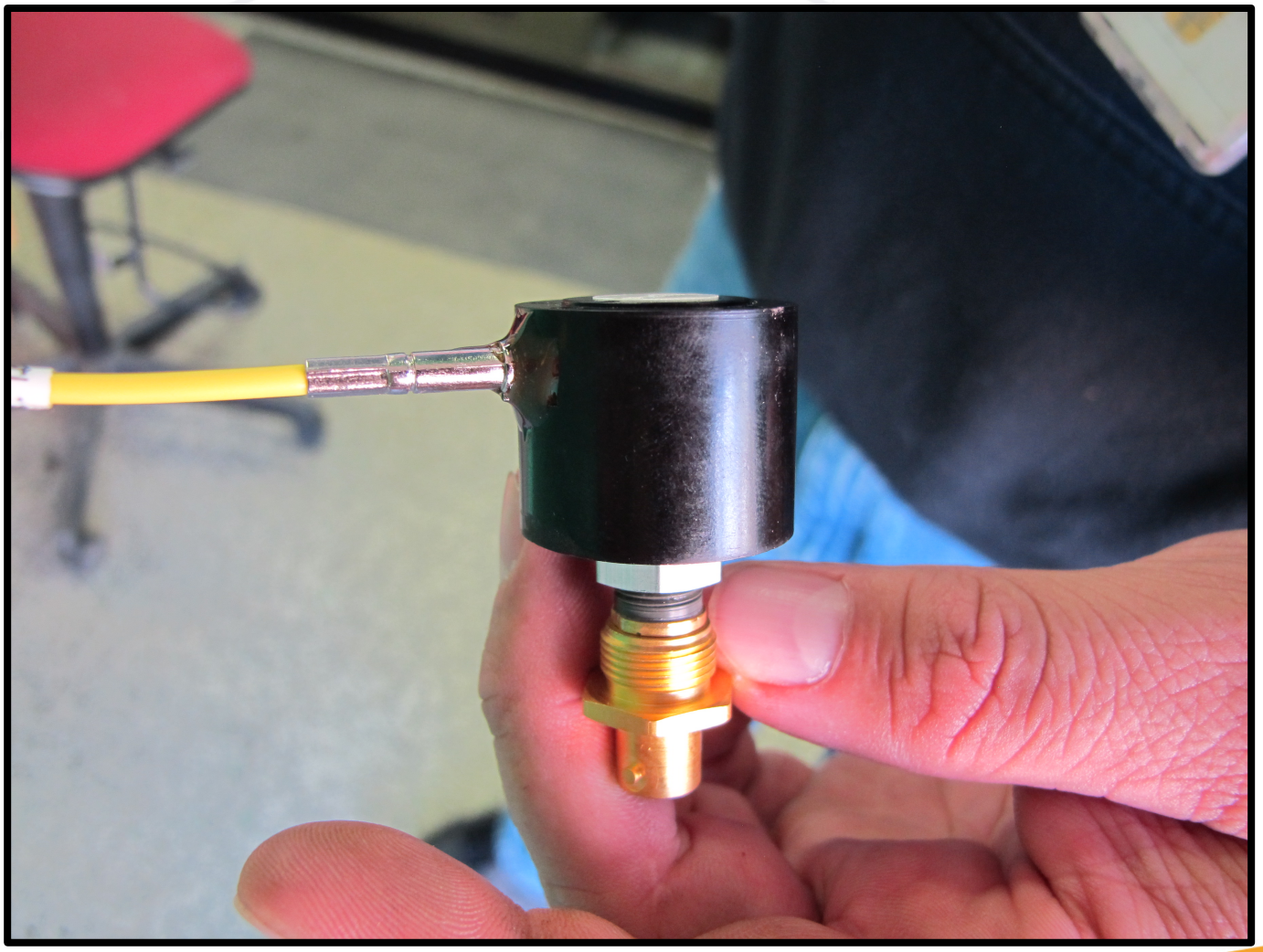
Fiber Optic TOAD Data with .010” shim stock



TOAD shock arrival time vs. PDV start of motion.



Sweeping wave shot on bare HE.



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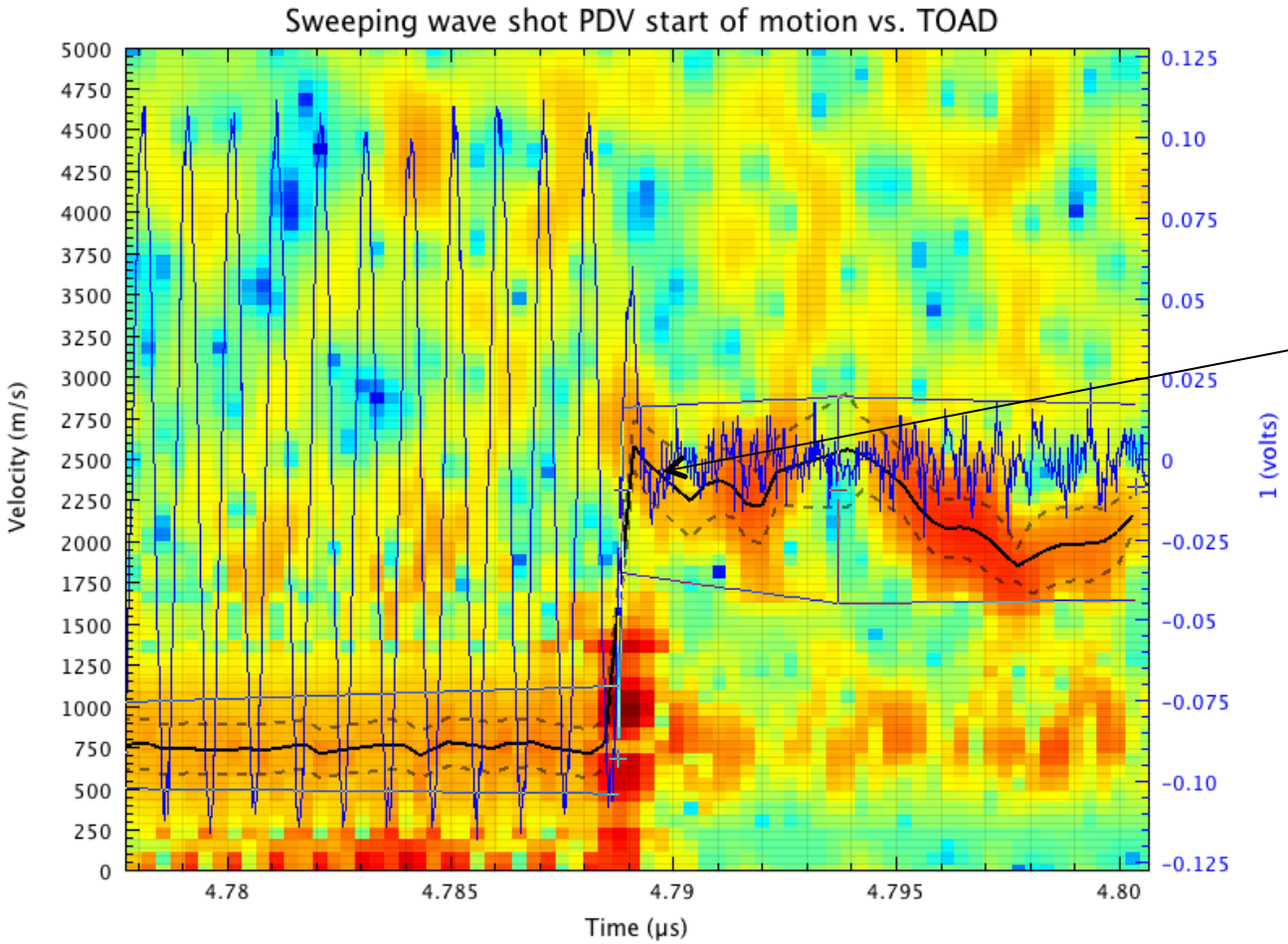
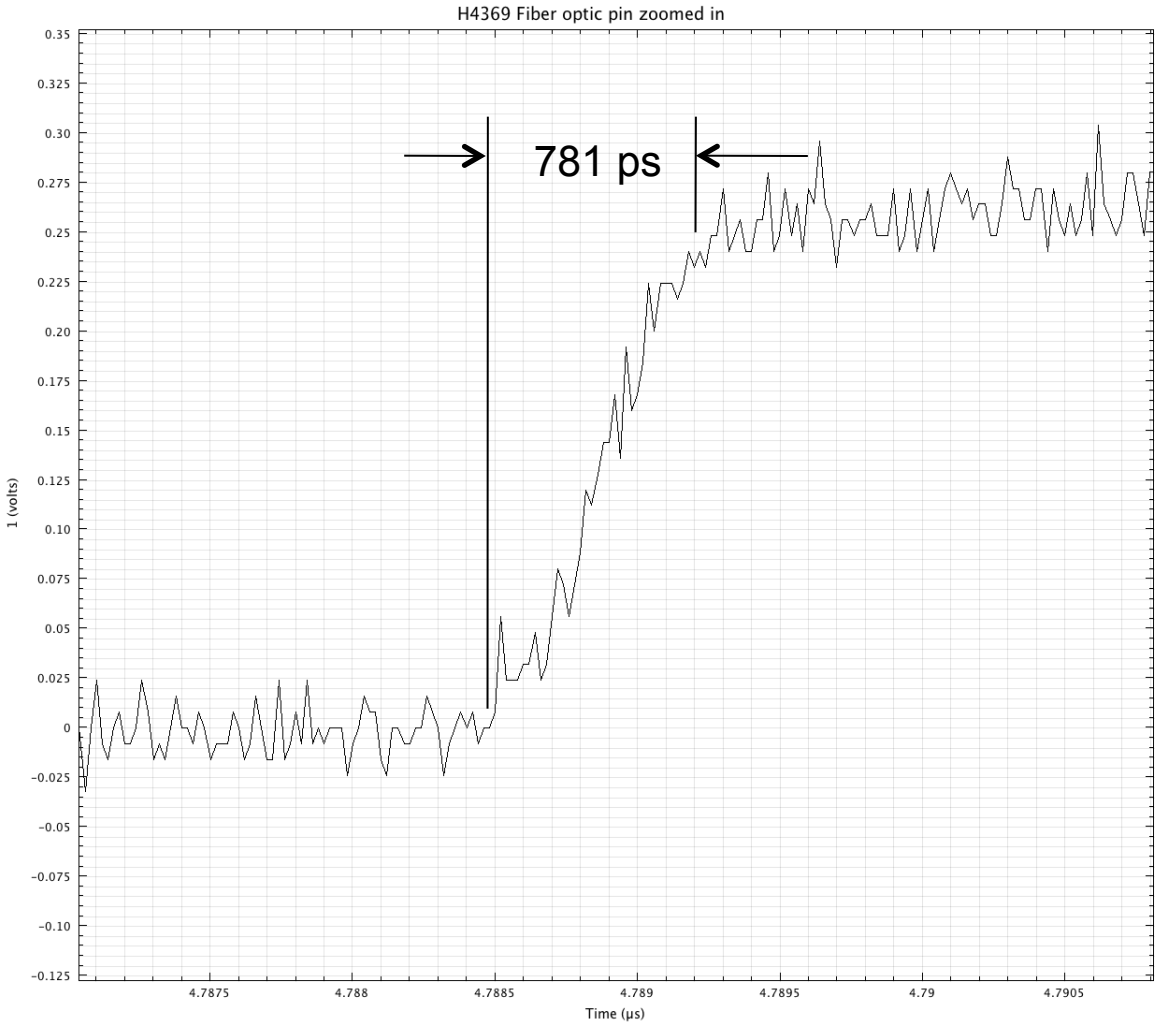
PDV sweeping wave results.



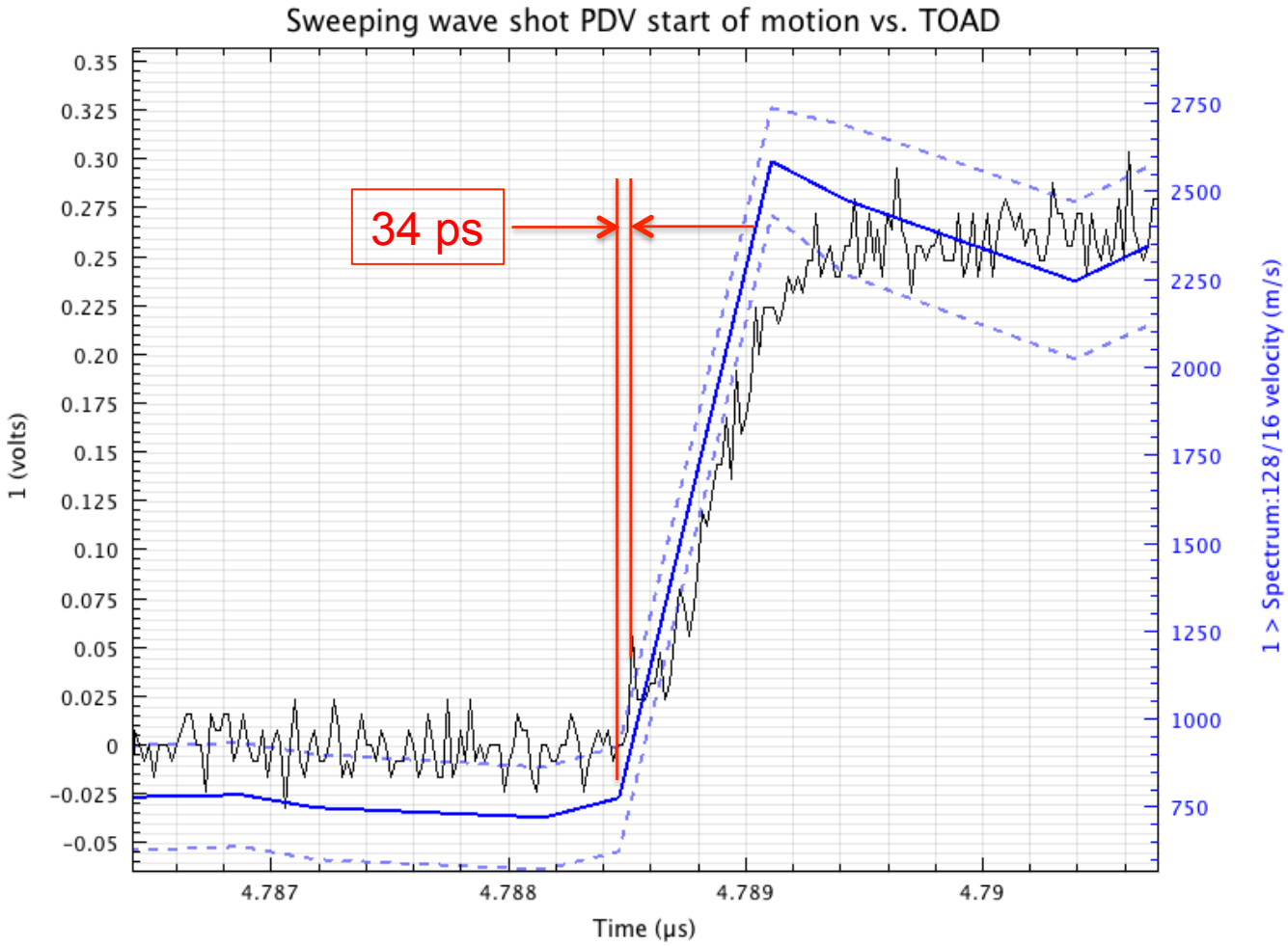
≈ 1.5 km/s

Window size 1.28ns
Window steps 160ps

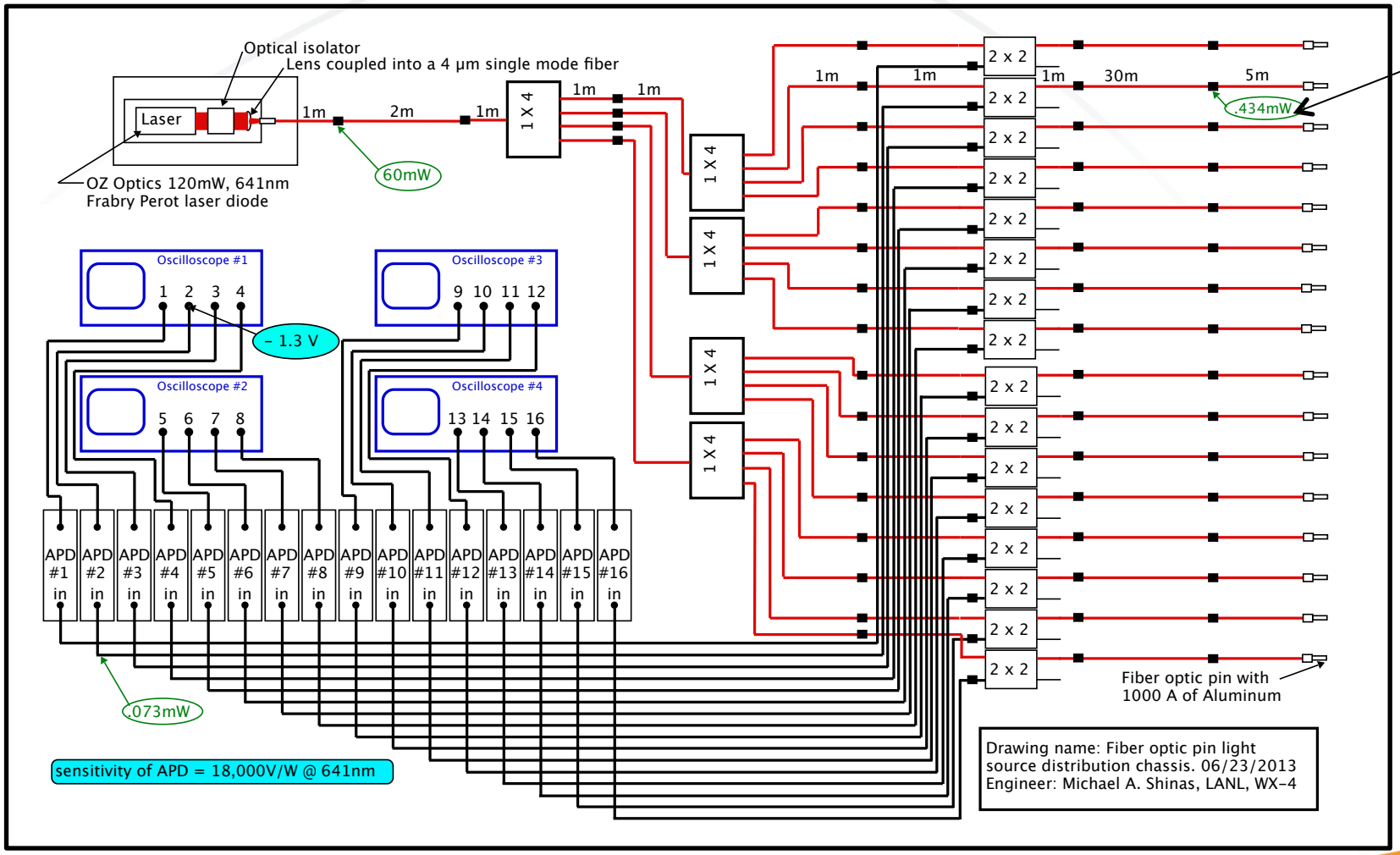
Fiber Optic TOAD sweeping wave arrival time.



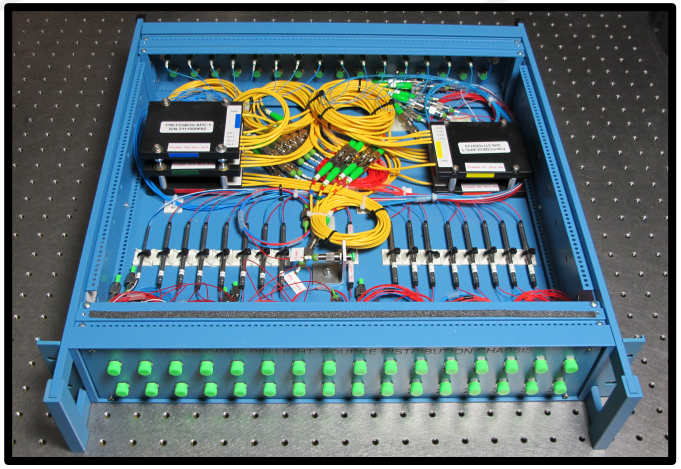
PDV start of motion vs. the Fiber Optic TOAD shock arrival time.

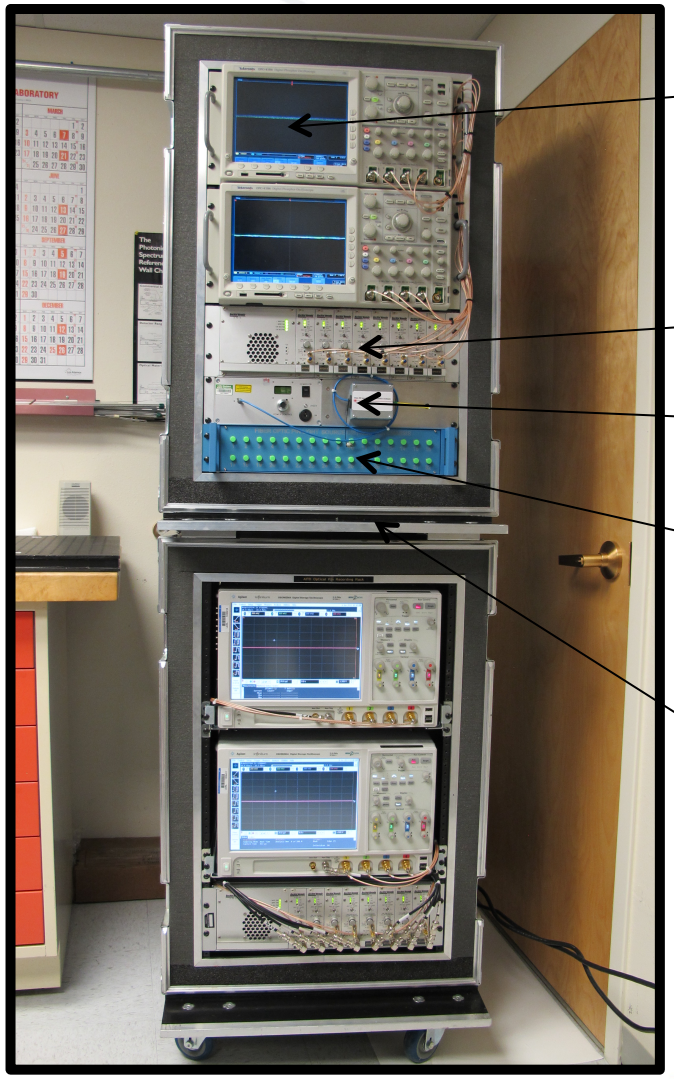


640nm Fiber optic TOAD system.



Portable 16 channel TOAD system.





Before the shot it's very easy to check if the fiber optic pins are working.

NSTec APD
DC-500 Mega Hz

Oz Optics
60 mW laser

light source distribution and return light chassis

To save room, one rack can be stack on the top of the other.

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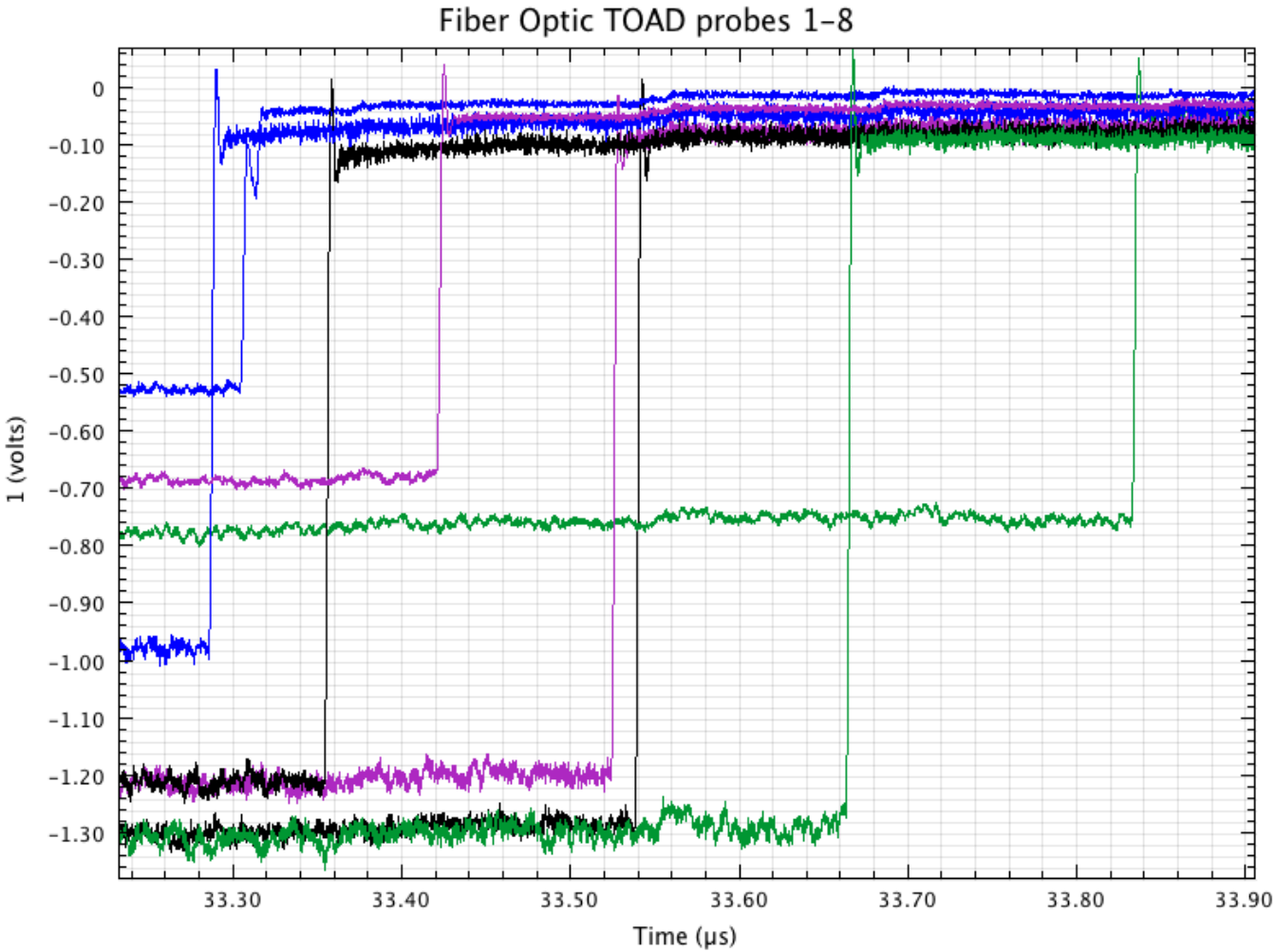
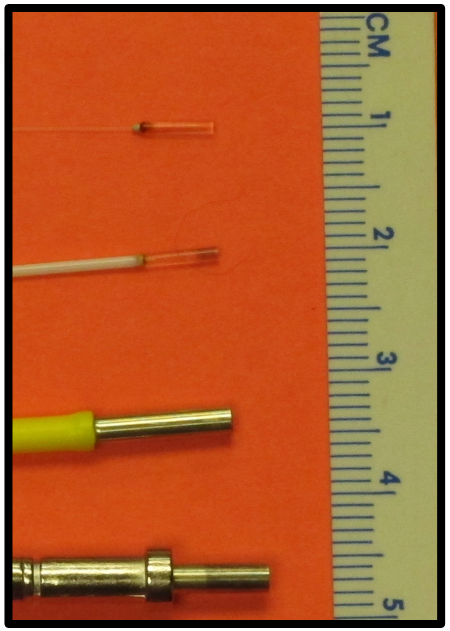
Data from the new 640nm TOAD system.



TOAD probes



Summary

- The PDV, proved experimental that the disappearance of the light reflected from the aluminum coating corresponds to the arrival of the detonation wave front.
- Demonstrated that the Fiber Optic TOAD will give a time of arrival normal to the HE or as the wave sweeps across the fiber optic pin.
- A Fiber Optic TOAD can measure the arrival of a shock wave through a .010” thick SS shim.
- Designed and build a Class 1 laser portable 16 channel Fiber Optic TOAD system.
- The active area of the fiber optic is very small only 4.3µm and the outer diameter tolerance is ± 0.5 µm. This will giving you a shock break out time at a very exact location.